

PRODUCTION OF BIOETHANOL FROM SORGHUM WASTE

UNIVERSITAS MUHAMMADIYAH SURAKARTA



PUBLICATION

**Arranged to fulfill the requirements of completing study in Bachelor Degree
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By:

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**DEPARTMENT OF CHEMICAL ENGINEERING
FACULTY OF ENGINEERING
UNIVERSITAS MUHAMMADIYAH SURAKARTA**

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VALIDATION

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NIK:100.892

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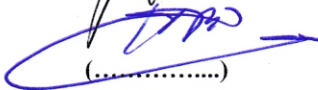
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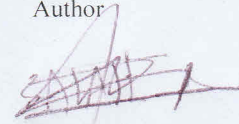
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Surakarta, 23 May 2017

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Abstract

The great need for energy and the problems of environmental pollution make it necessary for the use of bioethanol as an alternative energy produced from renewable and eco-friendly resources. Sorghum can produce sugar, grain, bran and biomass which can be used as raw materials to produce bioethanol. The present study used the bran and biomass which are sorghum waste to produce bioethanol. The process of bioethanol production from bran and sorghum waste consists of a number of stages including pre-treatment using NaOH, hydrolysis, fermentation, and two step distillations finally produce bioethanol 99% used for fuel. Conditions for pre-treatment and hydrolysis are made varied at 24 hrs., 48 hrs. and 72 hrs. in order to maximally produce bioethanol. Fermentation was carried out using the yeast of *Saccharomyces cerevisiae*. Based on the results of this study, it is expected that sorghum which can be grown easily in Indonesia especially in rural areas can be utilized both as a resource of energy.

Keywords: bioethanol, biomass, enzymatic hydrolysis, sodium hydroxide, sorghum

1. INTRODUCTION

Indonesia's energy demand is increasing every year. Bioenergy plants are expected to be one of the solutions to fill energy demand in Indonesia. Sorghum is a bioenergy plant that can be used in Indonesia for producing bioethanol. Sorghum bioethanol is produced from sorghum biomass waste processing results with fermentation process. Ethanol is derived from fermented sorghum which is about 40-55%. Sorghum bioethanol can be used as an alternative fuel that is renewable and can be used as a substitute for fossil fuels (Rahayu,2013).

Sorghum which scientific name is *Sorghum bicolor L.* is also known as *White Durra*, *Brown Durra*, or *Milo*. In Java, it is known as *cantel*. It is a type of crop that is highly adaptable and can grow in extreme climatic conditions. the straw or bagasse of sweet sorghum is an abundant and low-cost lignocellulosic material that can be synthetically used as a raw material for ethanol production with some byproduct with high additional value (Phuengjayaem and Teeradakorn, 2011).

Sorghum has a multiuse benefit. In addition, the seeds used as food, stems and leaves for fodder, the sugar contained in the seeds (carbohydrate) or liquid / juice / sap stem (sweet sorghum) can be processed into bioethanol. Sap is made from sorghum can used for bioethanol industry has developed in many countries such as USA, China, India and Belgium. Nowadays, the productivity of sorghum bioethanol in the United States totaled 10000 liters/ha, India 3000-4000 liters/ha and China 7000 liters/ha. As biofuels, sorghum bioethanol used in various purposes, such as blended with gasoline (premium) for motor vehicles. The world's sorghum production is comparable to the production of other staple crops such as corn, wheat and rice (Sergio and Esther, 2009).

Another advantage which this sorghum crop offers is its resistance to both biotic and abiotic factors (Prasad et al., 2007). Sorghum requires only one-third of water needed by corn and wheat. This will help farmers in dry areas when the dry season comes. Currently, in dry areas such as Gunung Kidul and Wonogiri, sorghum bran (biomass) is widely used as fodder (Mei Ying & Guiying, 2006).

The problem is an increase by nearly 50% of primary energy demand since 2010 has been accompanied by reduced production which initially was 1.6 million barrels per day into 861,000 barrels per day (Pertamina, 2015). Therefore, providing alternative energy is the only option to take to meet future energy need. For example, the Environmental Protection Agency (EPA USA) has established a rule on the use of alternative energy from cellulose (EIA, 2016). (Prasad & singh, 2007)

At first, bioethanol production was derived from a variety of plants, either food or non-food plants which contain starch or sugar through fermentation processes. This bioethanol production is often called the first-generation bioethanol production. However, this production has a disadvantage in terms of food insecurity because food is used for the production of bioethanol. This problem gave birth to the second-generation bioethanol made using leftover materials of solid plant waste or waste or non-food materials containing lignocellulose such as rice straw, corn cobs, and many more. The third-generation bioethanol makes the use of dried algae as the raw materials, the draining process of algae which takes a long time. Therefore, the second-generation bioethanol is considered more vital in the energy crisis since its use can solve the world's energy crisis and does not threaten food security. (Mehmood & Mohammad , 2009).

Corridor et al. (2006) in their research used bran from the decortication process (10%). The estimated chemical composition of this bran consisted of 30% of starch, 18% of hemicellulose, 11% of cellulose, 11% of protein, 10% of crude fat, and 3% of ash. The methods of pre-treatment and enzymatic hydrolysis carried out on this bran which actually is sorghum waste required heating water until it reached a temperature (10% solid, b/v) of 130° C for 20 min, acid hydrolysis (H₂SO₄), starch degradation and enzymatic hydrolysis (60 hours, 50° C, 0.9 %, v/ v). This combination of starch degradation, optimal water heating and optimal enzymatic hydrolysis resulted in a maximum total of up to 75% of sugar. (Corredor et al., 2006).

Although fungi, bacteria, and yeast microorganisms can be used for fermentation, specific yeast (*Saccharomyces cerevisiae*) is often used to ferment glucose into ethanol. Theoretically, 100 grams of glucose produces 51.4 g of ethanol and 48.8 g of carbon dioxide. Materials requiring flour starch reaction with water (hydrolysis) to break down the starch into fermentable sugars (scarification). There are three basic types of making ethanol, the acid hydrolysis process, enzymatic hydrolysis, and thermochemical-with variations for each one (Badger, 2002).

2. METHODS

2.1 Preparation of raw materials

First step is cut the rod into small pieces to make it easy when smoothing, then let the small pieces dry under sun ray during three days to make it easy when smoothing process, after the rod is dry, smoothed use blender and screen with screening 40 mesh.

2.2 Pretreatment

Substrate (rod of sorghum) which has the form of powder addition with water and sodium hydroxide (NaOH), in here using different concentration of sodium hydroxide, it's 1N, 3N, and 5N at the temperature is 120°C during one hours under pressure is 20 psig. After heating the mixture with different concentration, cooling the mixture until room temperature then all of mixture between substrate, water and sodium hydroxide will be neutralizes by hydrochloric acid until the pH is 7.

2.3 Hydrolysis

Hydrolysis under temperature is 55 - 60°C with the pH of is 4,5 - 5 during specific time, 24 hours, 48 hours and 72 hours, this step has a function for break of complex sugar into simple sugar. So, all of mixtures from before step must be make a pH is 4.5 – 5.5 or basic from enzyme that used in this process, after pH is make it, addition with enzymes is cellulase, and put into the water bath in every hour.

2.4 Fermentation

fermentation doing as anaerobic with addition yeast is *Saccharomyces cerevisiae* during 3 days in every substrate after hydrolysis, fermentation have to make an ethanol. Before doing fermentation, *Saccharomyces cerevisiae* must be condition with substrate from low volume until optimum volume for prevent the yeast will be dead.

2.5 Distillation

Distillation doing for get pure ethanol from result of fermentation, the step is result from fermentation will be purification use distillation tools, and second step is result from first distillation will be purification again with membrane until get the content of ethanol is 99-99, 9%.but in this research distillation only one step and the content not achieve 99-99,9%.

2.6 Analysis Methods

a Analysis of glucose

Glucose that result from hydrolisis process can analyzed use Nelson Somogyi methods. Equation that can applicated in the glucose analysis use nelson somogy is :

Glucose content (X) =

$$(X) = \frac{A}{B}(Y) + \frac{1}{B}$$

Note :

X = Content of glucose (%)

A, B = Reagent factors

Y = Volume of titrant

b Analysis of Ethanol

Ethanol that get from fermentation process can measuring of content or anlysis content GC (Gas Chromatography). Take the substrate result from fermentation as 10 mL and filter using paper filter and then take the filtrat and put into bottle sample. Then the substrate sahaker during 15 hours at the velocity is 1000 rpm. Then the solution ready to inject into GC tools (Agilent 6890N).

3. RESULTS AND DISCUSSIONS

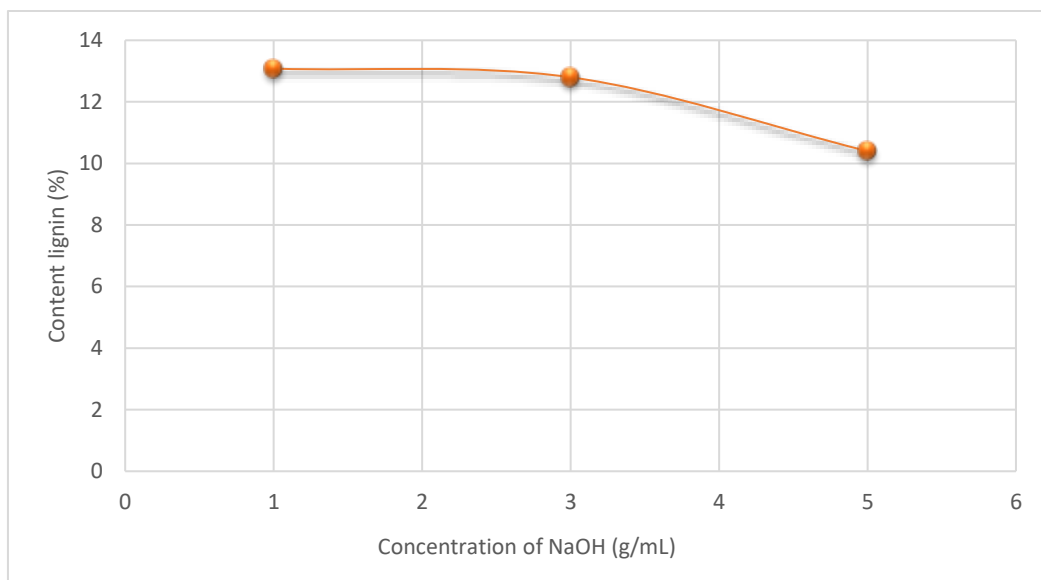


Figure 1. The effect of NaOH concentration to lignin content

Figure 1 show the effect of NaOH concentration to lignin content, Lignin very resistant to degradation, as biology, enzymatic or chemical. So, lignin can damage at high temperature and use high concentration of base, this is like a chemical method to open or damage the lignin until the cellulose in lignin can get through hydrolysis. From the result that get can show that content of lignin before doing treatment higher compared with result after doing pretreatment using base solution, in here using base solution is NaOH (sodium hydroxide) with concentration is 5N that only get the value is 9,06 %.

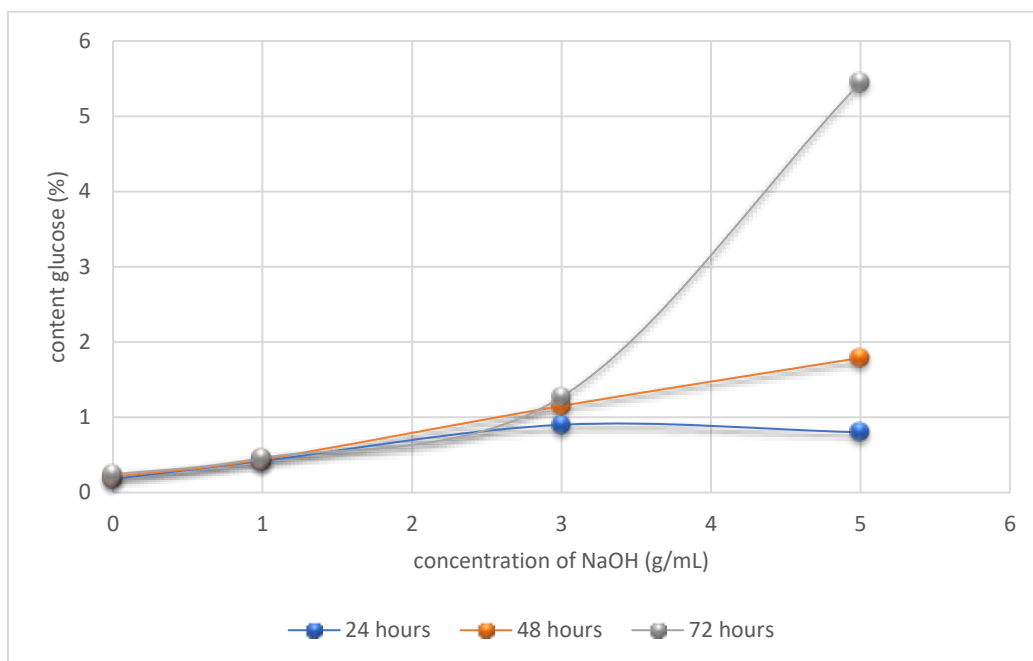


Figure 2. The effect of hydrolysis time to glucose content

Figure 2 show the effect of hydrolysis time to glucose content which shown more long time that used in the hydrolysis process and high of concentration that used in the before of hydrolysis process so higher also the glucose content that produce from the sample. This is can happen because at hydrolysis process there is damage or broken of crystal structure from cellulose also increase porosity of the material. Broken of the structure crystal will easy to decomposition cellulose into glucose. The other reason is hemicellulose will decomposition into glucose substance, like a glucose, galactose, mannose, hexose, penthouse, xylose and arabinose. Which decomposition usually require long time. Caused from this time optimum to hydrolysis is more long than other, 72 hours at the high of concentration base is 5 N.

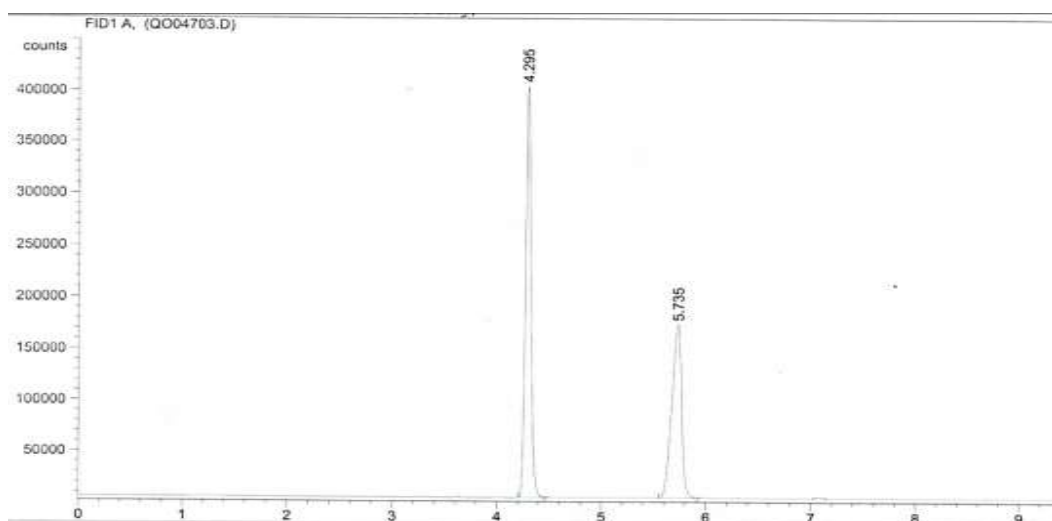


Figure 3. ethanol content analysis using gas chromatography.

From this figure about content of ethanol, we can get the equation : $Y = 0,66x + 0,306$ So content the ethanol is 0,58% at the sample using concentration of base is 5 N and time to hydrolisis is 72 hours also time for fermentation process is three days using *S.Cerivisiae*.

CONCLUSION

From the research of bioethanol from waste of sorghum plant, so can get the conclusion like this:

- 1 Waste of sorghum as biomass, actually can used to make alternative energy like bioethanol.
- 2 Base condition in pretreatment process can damage the lignin in the waste of sorghum as raw materials until the lignin is degradation and cellulose can be hydrolysis, optimum concentration of base to damage the lignin is 5 N.
- 3 Hydrolysis using enzyme actually can optimum, if condition of substrate can make enzyme not damage. In this research condition operation at hydrolysis process is 50 o C and pH of substrate is 5,5.
- 4 Time optimum to get the maximum of glucose is 72 hours with concentration base in pretreatment process is 5 N and using enzyme cellulose.
- 5 Fermentation process using yeast is fermipan with time is 3 days.
- 6 Distillation process get the result is 10 mL every 250 mL of substrate.
- 7 Analysis of ethanol content using gas chromatography, and get the result is 0,5 %.

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